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A laboratory taught by a graduate assistant, a programed instruction textbook, and computer-assisted instruction (CAI) were evaluated comparatively as supplemental instruction in a graduate course entitled "Statistical Methods in Education" at the State University of New York at Buffalo. The experimental population of 64 students was divided unevenly and at random to represent each of the three treatments. Evaluation was based on two factors related to course objectives: cognitive material learned and student "affect" determined by questionnaire. While the study revealed no significant differences among the supplementary media used, students received the programed materials more favorably than the laboratory. To strengthen experimental controls, a revised CAI program and additional tutorial help are indicated. (TI)

STATE UNIVERSITY OF NEW YORK AT BUFFALO

Instructional Communication Center

AN EVALUATION OF THREE INSTRUCTIONAL MEDIA AS SUPPLEMENTS TO A GRADUATE COURSE IN EDUCATIONAL STATISTICS

Traditionally, the introductory graduate statistics course offered by the Faculty of Educational Studies at the State University of New York at Buffalo (SUNYAB) supplements lectures with laboratory sessions conducted by a graduate assistant. It is believed that the laboratory sessions are desirable because they offer students certain learning opportunities that lectures do not permit; that is, opportunities to review topics covered in lectures and to ask questions related to homework problems. The intrinsic benefits of programmed instruction (self-pacing, immediate feedback, organization by concepts, and content-specialist authors) suggest that this medium could also function effectively as a supplement to lectures. It was the purpose of this study to plan and execute a comparative evaluation of three media used as supplemental instruction in an introductory graduate course in educational statistics. These media were: laboratory taught by a graduate assistant, programmed instruction textbook, and computer-assisted instruction. The evaluation was based upon two factors related to the course objectives: amount of cognitive material learned, and the degree of positive and negative effect associated with the media.

A. Procedure

1. Population

The population in this study was defined as those students who take "Statistical Methods in Education: Descriptive" under the present requirements of the various departments within the Faculty of Educational Studies, SUNYAB. It was not possible to determine how differences in department

requirements within the Faculty affect the description of the population. No assumptions were made regarding the composition of this population with respect to variables affecting learning. That is, no data were available on intelligence quotient scores, previous statistics courses, and degree of mathematics sophistication. It was assumed, however, that the distributions of these variables do not change substantially from year to year.

2. Sample

Under the foregoing assumptions, the class taught during the fall, 1967, semester may be regarded as a random selection from the population under study. The original enrollment in the class consisted of seventy-five students, with twenty-five students randomly assigned to each treatment group. However, two students assigned to the computer-assisted instruction (CAI) group were unable to commute to the University during the week to use the terminal and were reassigned to the programmed textbook group. An additional two students assigned to the CAI group chose not to use the medium and were dropped from the sample. One student assigned to the laboratory also had commuting difficulties and was consequently reassigned to the programmed textbook group. By January, nine students had dropped the course. Thus, the total sample size for the analysis was reduced to sixty-four with distributions as follows: CAI group, nineteen students; laboratory group, twenty students; and programmed textbook group, twenty-five students. (For analysis of the final results, the total sample size and the distributions required further adjustment as discussed under B. Results.)

3. Criteria Measures

The course objectives included familiarity with introductory content in descriptive statistics and ability to manipulate the concepts presented.

Actual computation, while a specific goal, was not emphasized.

Instruments (the final exam and the two mid-term exams) were created by selecting items from a pool of such items which had been developed from previously used and tested items. The test items had high discrimination indices (greater than 1) and acceptable difficulties (between .40 and .60).

To begin a long-range study of the attitudes of college students toward programmed instruction, a series of open-ended questions was developed. To complement these questions, three yes-no questions were asked those students who received CAI. The questionnaire can be found in the Appendix.

4. Treatments

Three treatments were compared; these were a CAI program, a programmed textbook, and laboratory sessions conducted by a graduate assistant.

The CAI program was an introductory course in descriptive statistics written by James Schoonard for Science Research Associates; it was available through computer hook-up with an IBM 7010 central processor located in Yorktown Heights, New York. Console times were scheduled, and students were told that additional time would be available if they required it. After an orientation session, the students were told to follow the instructions given in the CAI workbook. Proctors were on duty to handle scheduling problems and assist with console and communication problems.

The programmed textbook was Basic Concepts in Statistics by McCollough. Students were instructed to complete the text at their own pace.

The format of the laboratory conducted by a graduate assistant was not altered from that of previous semesters. It was informal and presented so that questions and discussion related to either homework or lectures were welcomed.

Attendance at the lecture sessions was not compulsory. The lectures were given in conjunction with assigned readings in Weinberg and Schumaker's text Statistics: An Intuitive Approach. All students were required to complete six homework assignments. These assignments were corrected and graded. If a student made major errors in these assignments, he was required to correct them and hand in the corrected work.

5. Design

Analysis was conducted on both the cognitive and affective levels. Procedures for the analysis of each area were as follows:

a. Cognitive

The cognitive analysis was concerned with testing the hypothesis:

Ho: There are no differences among treatment levels with respect to final grades.

Accordingly, a one-way, fixed analysis of variance was run. The three levels of the treatment variable were CAI, programmed textbook, and graduate assistant-taught laboratory; the dependent variable was final grade. The final grade was a numerical composite score of the two mid-term exam grades and the final exam grade. The statistical tests were made at the .05 confidence level. Appropriate Scheffe post-hoc comparisons were to be made if the three group means proved significantly different.

b. Affective

The questionnaire given to the students is considered an initiative step in a long-range study of students' attitudes toward CAI. For this reason the main questions were open ended.

The questionnaire was administered to the students after they had completed their final examinations. It was decided that students would be more likely to express their true attitudes if they were not required

to sign their names; therefore, the questionnaire was anonymous and students were encouraged to give spontaneous comments. Analysis of the questionnaire was a descriptive report of frequencies.

B. Results

1. Cognitive

The analysis of variance produced an F of .03. The tabled F for two and sixty degrees of freedom at $\alpha = .05$ is 3.93. Therefore, the hypothesis that there are no differences among levels with respect to final grades is not rejected.

The results of the analysis of variance are given in Table 1.

Table 1

Analysis of Variance

Source	d.f.	M.S.	F
Between	2	27.81	.03
Within	60	807.87	
Total	62	835.68	

Note.--One student assigned to CAI never reported and thus his grade was dropped from the sample.

If it is desirable to make inferences to the population, it could be concluded that for the population, instructor, graduate assistant, and programmed materials studied, there are no significant differences between graduate assistant-taught laboratory, programmed textbook, and CAI as supplemental teaching media.

2. Affective

The questionnaire requested students to check the group to which they had been assigned. The frequencies shown in Table 2 indicated discrepancies between the assigned cell totals (after attrition) and the reported assignments.

Table 2

Discrepancies in Assigned Group and Student-Reported Group

	Assigned	Student-Reported
CAI	19	15
Programmed Text	25	27
Laboratory	20	20
Total	64	62

Since the questionnaires were anonymous, it is not known to what extent the student reports correspond to original assignments. The following discussion, therefore, is based on the assumption that the medium checked is the medium at which the student focused his responses. The specificity of the responses in all cases indicates that this assumption is valid.

The following discusses student responses for each of the media:

a. Laboratory

Of the twenty students who indicated that they had been assigned to the graduate assistant-taught laboratory, five students stated that they had attended the laboratory and fifteen students stated that they had never attended the laboratory. In response to the question asking for

average amount of time spent per week in the laboratory, the five students who indicated they had used the laboratory reported the amounts of time as given in Table 3.

Table 3

Student-Reported Use of Graduate Assistant-Taught Laboratory

Student	Reported Time Used Laboratory
Student 1	Once for 30 Minutes
Student 2	Twice for 30 Minutes Each Time
Student 3	Weekly: 2 hrs./week
Student 4	Weekly: 3 hrs./week
Student 5	Weekly: 3-5 hrs./week

Reasons for lack of attendance at the laboratory are not known; however, several unsolicited comments indicated scheduling difficulties.

In response to whether they liked the laboratory and if they found the method effective, the five students commented as indicated in Table 4.

Student 2 (see Table 3) reported that he also made use of the programmed textbook, and another student who did not attend the laboratory indicated that he used the programmed textbook from two to four hours per week.

b. Programmed Textbook

Table 5 indicates the amount of time per week that students reported using the programmed textbook. It should be noted that the total

Table 4

Frequencies of Students Reporting Effectiveness of Graduate Assistant-Taught Laboratory and Breakdown with Respect to Liking the Medium

Found Lab Effective		Did Not Find Lab Effective	
Liked	Did Not Like	Liked	Did Not Like
1	1		1

Note.--One student did not find lab effective yet had ambivalent feelings with respect to liking and not liking the medium.

One student indicated he found the medium both effective and noneffective.

Table 5

Reported Amount of Time Spent Using Programmed Textbook

Number of Students	Time/Week
3	0 hrs.
7	Less than 1 hr.
7	1 hr.
6	2 hrs.
1	3 hrs.

number of students is only twenty-four; two students did not respond to the question, and one student indicated that he used the programmed textbook but was unable to arrive at a time estimate.

Student responses to the questions asking opinions as to effectiveness and liking of the programmed textbook are summarized in Table 6.

Table 6

Frequencies of Students Reporting Effectiveness of Programmed Textbook and Breakdown with Respect to Liking the Medium

Found P.T. Effective		Did Not Find P.T. Effective	
Liked	Did Not Like	Liked	Did Not Like
14	2	5	6
16		11	

Table 7 indicates subjects' comments on the programmed textbook. Among the are responses to the questionnaire and unsolicited comments. They have been classified by content and positive and negative effect and grouped together under the broadest response. Thus, "easy to read and understand" includes "reduced the material to a basic level" and "simple."

c. Computer-Assisted Instruction

The fifteen students who reported being assigned to the CAI group all indicated that they had used the program. One student stated that he also received outside tutoring. The actual amount of student time spent working at the computer, as calculated from the print-outs, is shown in Table 8. It is difficult to tally average amount of time spent per

Table 7

Student Comments Regarding Programmed Textbook

Comments	Frequency
Positive Comments	
Easy to read and understand	8
Clarified concepts	5
Liked proceeding at own rate	2
Required little additional work	1
Convenient	1
Liked knowing answers immediately	1
Total	18
Negative Comments	
Steps too small	5
Not enough time	4
Confused by differing approaches	3
Not sure of effectiveness	2
Preferred scheduled time	2
Program confusing	1
Too fast	1
Total	18

Table 8

CAI Group: Chapters Completed, Final Grades, and Total Console Time

Student	Statistics Chapters												Final Grade	Total Time on CAI Console
	1	2	3	4	5	6	7	8	9	10	11	12		
1	X	X	X	X	X	X	X						A	7 hrs. 24 min.
2	X	X	X	X	X	X	X						B	6 hrs. 18 min.
3	X	X	X	X	X	X	X	X	X	X	X		A	6 hrs. 52 min.
4	X	X	X	X	X	X	X	X	X	X	X		A	5 hrs. 30 min.
5	X	X			X		X						B	4 hrs. 22 min.
6	X	X	X	X	X	X	X	X	X	X	X		B	7 hrs. 19 min.
7	X	X	X	X	X	X							A	6 hrs. 6 min.
8	X	X	X	X	X		X	X	X	X			B	18 hrs. 6 min.
9	X	X	X	X	X	X	X	X		X	X	X	B	15 hrs. 5 min.
10	X	X	X	X	X	X							C	11 hrs. 18 min.
11	X	X											B	2 hrs. 54 min.
12	X	X		X	X								B	7 hrs. 9 min.
13	X	X	X	X	X	X							B	6 hrs. 23 min.
14	X	X	X	X	X	X	X						B	9 hrs. 55 min.
15	X	X	X	X	X	X	X						B	4 hrs. 26 min.
16	X			X	X	X	X	X	X	X	X		C	8 hrs. 7 min.
17	X				X								C	2 hrs. 11 min.
18	X	X											B	2 hrs. 19 min.

Note.--"X" means that the student completed the corresponding chapter.

week working with the CAI console and with the workbook because some students indicated the time varied and others reported the time decreased as they lost interest in the medium. The range in time reported was from one hour per week for four weeks to ten hours per week for the semester.

Responses as to the effectiveness and liking of CAI were mixed. It appears that students who thought CAI effective also liked it; students who believed CAI ineffective disliked the medium. The responses are shown in Table 9.

Table 9

Frequencies of Students Reporting Effectiveness of CAI and Breakdown with Respect to Liking the Medium

Found CAI Effective		Did Not Find CAI Effective	
Liked	Did Not Like	Liked	Did Not Like
7	1	0	7
Total: 8		Total: 7	

Only three of the fifteen CAI students indicated difficulty in learning to type their responses. These three students also indicated that they found confusing the differences between the symbolic notation used in the CAI program and that used by the instructor. Of the twelve students who had no typing problems, eight found the symbolic notation confusing. Five students would have preferred a program having no workbook but requiring instead direct answering of all questions at the console. These responses are summarized in Table 10.

Spontaneous positive comments of the CAI group to aspects of computer-

Table 10

Response Frequencies to Questions Concerning CAI

Question	Response Frequencies		
	Yes	No	Total
Difficulties in Typing	3	12	15
Symbolic Notation Confusing	11	4	15
Prefer Full-Time Computer	5	10	15

assisted instruction were primarily concerned with the nature of the material programmed; however, the negative comments seem to indicate that the students expected more from the computer with respect to flexibility, amount in storage, and ability to respond. Students' comments on CAI are given in Table 11.

Examination of the computer print-outs shows that the eighteen students who were assigned to the CAI group and who completed all of the lecturer's course requirements spent, for the semester, an average of seven hours and nineteen minutes on the CAI console. Examination of Table 8 reveals that there was a great diversity in total amount of CAI time, ranging from over two hours at the console for student 17 to over eighteen hours for student 8. While there does not seem to be any relationship between total time spent at the console and final course grade, it should be noted that each of the four students receiving an A as a final grade spent at least five and one-half hours at the console. Table 8 also indicates the number of chapters each student completed. Over half (ten)

Table 11

Student Comments Regarding CAI Course in Statistics

Comments	Frequency
Positive Comments	
Indicates errors	2
Appreciated additional work	2
Forced to understand terminology	1
Helped with thinking in statistics	1
Appreciated guided lessons	1
Forced to answer questions otherwise neglected	1
Total	8
Negative Comments	
Angry or frustrated with machine	6
Would like to ask (machine) own questions	4
Machine not available	4
Machine explanations too lengthy	1
Too time consuming	1
Desires more time	1
Rejects correct answer	1
No flexibility in schedule	1
Sequence out of phase with class	1
Questions not applicable to class	1
Assumed too much sophistication in statistics	1
Total	22

of the students completed the first seven CAI chapters. These chapters constituted the primary emphasis of the course as taught by the lecturer. Again there is no correspondence between chapters completed and grades; yet, one notices that each of the "A" students completed at least the first six chapters.

Table 8 reveals what was probably one of the most important contributions of CAI as a teaching medium; that is, it allows the student the opportunity to go beyond what is offered in the classroom. Analysis of variance (ANOVA) was the topic of the last class lecture. Students received neither homework nor examination questions pertaining to this topic. There was no course-oriented reason for any student to pursue the topic. Yet, one of the CAI students completed the ANOVA chapter in the CAI. Although he could have borrowed an ANOVA book from the library, it may be that the CAI program allowed him to continue his study in a program that was geared to his ability and that used familiar notation.

C. Discussion

While this study did not reveal significant differences among the supplementary media used, student comments on the questionnaire indicated that the programmed materials were more favorably received by the students than was the laboratory. Many students seemed to appreciate the tutorial method provided by the programmed textbook and CAI. Much of the criticism of CAI was not directed at the concept of computer-assisted instruction, but rather at the limitations of the program and scheduling difficulties. Because this statistics CAI program was a prototype, these program criticisms are to be expected; also the Instructional Communication Center has gained valuable information as to appropriate mechanical and clerical procedures for running a CAI course.

It is pertinent to this discussion to mention several factors which may have affected the experimental results. Many unsolicited comments on the questionnaire praised the instructor for his fine teaching. Several students commented that the statistics course had been one of the best courses they had taken at the University. It is very possible that the instructor's influence in this situation constituted the actual source of treatment effect. Further, it cannot be assumed that within each level of treatment all students received the same amount of treatment. It was possible to eliminate the one student who did not use CAI; however, Table 8 clearly shows that many students did not complete the first eleven chapters. Table 5 shows the wide variety of time devoted to the programmed textbook. The limited use of the graduate assistant-taught laboratory suggests that this group functioned primarily as a control group. In addition to the varying amounts of treatment, three students admitted to having used an additional supplementary medium than that to which they had been assigned. Also, a graduate student in the educational statistics and evaluation area reported that she tutored three students in this introductory course. Only one student reported receiving tutorial help; it is, therefore, not known how many students in this sample actually did seek tutorial assistance.

In conclusion, the results of this study suggest replicating the study using stricter controls, such as another instructor and graduate assistant and another or a revised CAI program.

APPENDIX

F 521 Questionnaire

The following questions are related to the supplementary instructional media available to you this semester. Your responses to this questionnaire will constitute one phase of evaluative research; therefore, please seriously consider your answers before responding to insure the integrity of the results. Do NOT sign your name.

1. Check the teaching group you were assigned to:

   _____ computer-assisted instruction

   _____ programmed textbook

   _____ graduate assistant-taught laboratory

2. If you made use of more than one of these instructional media, please list them below.

   _____

3. Indicate the average amount of time per week you devoted to the instructional medium to which you were assigned.

4. Did you find the instructional medium to which you were assigned effective as a learning method? Please explain.

   Yes No

5. Did you like the type of instructional medium to which you were assigned? Please explain.

   Yes No

Answer the following questions only if you were assigned to the CAI group.

6. Did you have trouble learning to type in your responses? ☐ Yes ☐ No

7. Did you find the differences between the symbolic notation used in the CAI program and in class confusing? ☐ Yes ☐ No

8. Would you have preferred a program that did not have a workbook, but instead required you to directly answer all questions at the console? ☐ Yes ☐ No